

Public Health Assessment

Final Release

SOUTHWEST JEFFERSON COUNTY MINING

JEFFERSON COUNTY, MISSOURI

EPA FACILITY ID: MON000705443

**Prepared by the
Missouri Department of Health and Senior Services**

JUNE 25, 2012

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 60-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Use of trade names is for identification only and does not constitute endorsement by the U.S. Department of Health and Human Services. Additional copies of this report are available from:

National Technical Information Service, Springfield, Virginia
(703) 605-6000

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: <http://www.atsdr.cdc.gov>

SOUTHWEST JEFFERSON COUNTY MINING

FINAL RELEASE

PUBLIC HEALTH ASSESSMENT

SOUTHWEST JEFFERSON COUNTY MINING

JEFFERSON COUNTY, MISSOURI

EPA FACILITY ID: MON000705443

Prepared by:

Missouri Department of Health and Senior Services
Division of Community & Public Health
Section for Environmental Public Health
Bureau of Environmental Epidemiology
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

TABLE OF CONTENTS

SUMMARY	i
PURPOSE AND HEALTH ISSUES	1
BACKGROUND	1
Site Description and History	1
Site Investigations	2
Other Sources of Exposure to Contaminants	6
Jefferson County Health Department Activities	6
Elevated Blood Lead Risk Assessment.....	7
Land Use, Natural Resources, and Geology	8
Physical Hazards	8
Demographics	8
Quality Assurance and Quality Control.....	9
DISCUSSION	9
TOXICOLOGICAL EVALUATION.....	11
COMMUNITY HEALTH CONCERNS	18
CONCLUSIONS.....	19
RECOMMENDATIONS	22
PUBLIC HEALTH ACTION PLAN	23
REPORT PREPARATION.....	24
REFERENCES	25
APPENDIXES	27
Appendix A – Figures	
Appendix B – Tables	

SUMMARY

INTRODUCTION

The top priority for the Missouri Department of Health and Senior Services (DHSS), in cooperation with the federal Agency for Toxic Substances and Disease Registry (ATSDR), in evaluating the public health impact of the Southwest Jefferson County Mining site is to provide the Jefferson County community with the best information possible to safeguard its health.

The Southwest Jefferson County Mining site is on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) primarily due to lead contamination of residential yards soils and private drinking water wells. The contamination is the result of mining, milling, and smelter wastes, and widespread use of lead contaminated soil for landscaping. To a lesser extent, there is concern for cadmium and barium in drinking water, cadmium and arsenic in soil, and physical hazards left behind from past mining activities.

CONCLUSIONS

DHSS has reached four important conclusions in this health assessment:

**Conclusion 1
*Mining Related Soil***

Ingesting (swallowing) and to a lesser extent inhaling (breathing) lead contaminated soil or dust for a year or longer at levels found in many of the residential yards within the Southwest Jefferson County Mining site may harm individuals' health. This conclusion applies to past, present, and future exposure to lead at this site.

Basis for Decision

Residential yards throughout the mining areas in the Southwest Jefferson County Mining site contain lead and infrequently arsenic and cadmium in soil at concentrations above a level of health concern. The primary concern from exposure to lead in Jefferson County is the effects lead has on the nervous system, especially on children less than 72 months of age.

EPA has removed soil from numerous residential yards with lead concentrations above EPA's Time-Critical Removal Action level. These yards contained soil with lead contamination at a concentration of 1,200 parts per million (ppm) and greater or lead concentrations of 400 ppm and above for those homes with a child less than 72 months of age with an elevated blood lead level.

Some residential yards with soil containing lead above EPA's Time-Critical Removal Action level, and numerous residential yards with soil containing lead at concentrations above EPA's standard health risk level of 400 ppm still remain. A future EPA Remedial Action is expected to clean up these yards where access can be gained. Exposure to the soil in these yards for a year or longer may harm people's health. Individuals, especially young children, can be exposed to this contaminated soil directly by accidentally ingesting the soil while playing or spending time in the yard. Contaminated soil can also be tracked indoors by shoes and pets and subsequently accumulate in the home. Young children, can accidentally ingest contaminated floor and windowsill lead containing dust in the home. Although it is a minor route of exposure, individuals can also be exposed by inhalation of contaminated dust in the yard and contaminated dust in the home. When this soil or dust is stirred up and becomes airborne, individuals, especially children, may breathe it in and then clear it from their lungs and swallow it.

All lead exposure sources are important to consider, as lead-based paint or other non-site related sources of lead along with non-traditional sources, such as folk remedies and toys, may add to these concerns.

Conclusion 2
Hauled in soil

Ingesting and to a lesser extent inhaling lead contaminated soil or dust for a year or longer from residential yards where lead-contaminated topsoil was hauled in may harm individuals' health, especially children less than 72 months of age. This conclusion applies to past, present, and future exposure to lead in these yards.

Basis for Decision

Residential yards throughout Jefferson County have been contaminated with lead contaminated soil that has been hauled from areas on the Big River floodplain to residential locations where it was used for landscaping and fill purposes. The primary concern for exposure to lead from these yards is the effects lead has on the nervous system, especially on children less than 72 months of age.

EPA is removing soil from residential yards with lead concentrations above EPA's Time-Critical Removal Action level. A future EPA Remedial Action is expected to clean up the soils with lead contamination above a health risk level in yards where access is allowed. For detailed removal information, see conclusion 1.

All lead exposure sources are important to consider, so lead-based paint or other non-site related sources of lead can add to these concerns.

Conclusion 3
Groundwater

For past, present, and future exposures to lead and, to a lesser extent cadmium, residents can be exposed via drinking untreated well water for a year or longer that can harm their health.

Basis for Decision

A number of private drinking water wells in the Southwest Jefferson County Mining site contained lead at concentrations greater than 15 parts per billion (ppb) or cadmium above 5 ppb. The primary exposure route to lead or cadmium contaminated water is through ingestion. The primary concern from exposure to lead is the effect lead has on the nervous system, especially on children less than 72 months of age. All lead exposure sources are important to consider, so lead-based paint or other non-site related sources of lead can add to these concerns. Long-term exposure to low levels of cadmium leads to a buildup of cadmium in the kidneys and possible kidney disease as well as lung damage and fragile bones.

EPA is currently using 15 ppb of lead and 5 ppb for cadmium as the site-specific action level for private well water in the Southwest Jefferson County Mining site as a guideline for providing temporary alternative sources of drinking water. For present and future exposures, those individuals who are using EPA provided temporary alternative sources of drinking water are no longer being exposed to contaminated water through ingestion.

For individuals who have refused EPA temporary alternative source of drinking water, they may still be drinking water from a contaminated private well. If these individuals are not drinking water from an alternative source or are not effectively filtering their well water, they may continue to be exposed to contaminants at levels that may harm their health.

Conclusion 4

DHSS cannot currently conclude whether exposure to lead through air, sediment, floodplain soils, surface water, fish, and edible plants in the Southwest Jefferson County Mining site could harm, or may have harmed individuals' health. Physical hazards are also expected to exist in the past mining areas. Information needed to make a decision is very limited.

Basis for Decision Area water bodies (streams and lakes), sediment, floodplain soils, and fish have not been sufficiently tested in the Southwest Jefferson County Mining site area to determine whether they contain elevated levels of contaminants or if physical hazards are present to cause injury. More testing and investigation is needed to determine whether they may harm individuals' health.

Next Steps

To protect residents:

1. Under a Time-Critical Removal Action, EPA is removing lead contaminated soil with levels of 1,200 ppm and greater. Also under the Time Critical Removal Action, for residences with a child less than 72 months of age with an elevated blood-lead level or an expectant mother, EPA is removing soil with lead contamination of 400 ppm or greater.
2. EPA should continue providing an alternate source of water to residents with elevated levels of lead or cadmium in their private drinking water wells until a permanent solution is identified and implemented.
3. EPA/MDNR should take additional samples of other media, such as air, sediment, surface water, flood plain soils, fish, and edible plants, to determine if exposure to these media may harm people's health.
4. DHSS/ATSDR will coordinate with the Jefferson County Health Department, MDNR, and EPA to provide community health education to the public and health professionals, encourage residences to have their yard soils and private drinking water wells tested and remediated if found elevated for contaminants, and address community concerns as they arise.
5. EPA/MDNR should eliminate physical hazards left from past mining processes when found.
6. DHSS/ATSDR will coordinate with Jefferson County Health Department, MDNR, and EPA to implement the recommendations in this public health assessment.
7. DHSS/ATSDR will assist Jefferson County Health Department in continuing to promote prevention of lead exposure from all sources and encourage residents of

Jefferson County to have yearly blood lead testing conducted for children less than 72 months of age and for expectant mothers.

8. DHSS/ATSDR will review and comment on any additional data from environmental samples collected by EPA, MDNR, or other agencies as it becomes available.

PURPOSE AND HEALTH ISSUES

The Missouri Department of Health and Senior Services (DHSS), in cooperation with the federal Agency for Toxic Substances and Disease Registry (ATSDR), is evaluating the public health impact of the Southwest Jefferson County Mining site. ATSDR is a federal agency within the U.S. Department of Health and Human Services and is mandated by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments at hazardous waste sites. In this public health assessment we will assess the public health implications of exposures to environmental contaminants and recommend actions to prevent or mitigate exposures.

The primary contaminant of concern in the Southwest Jefferson County Mining Site is lead in soil and drinking water from mining, milling waste, former smelter areas, and from using lead contaminated soil for residential and commercial landscaping. To a lesser extent, there have been infrequent instances when cadmium and arsenic were elevated in samples of soil or drinking water. This public health assessment will determine whether exposure to site related contaminants have occurred in the past, present, or future at a level of health concern and recommend actions to reduce or prevent exposure and possible adverse health effects.

BACKGROUND

Site Description and History

The Southwest Jefferson County Mining site includes all of Jefferson County, encompassing 664 square miles. Jefferson County is bordered on the north by St. Louis County and the Meramec River, on the east by the Mississippi River, on the south by St. Francois County and Ste. Genevieve County and on the west by Franklin and Washington Counties. For the purpose of investigating the contamination from past mining, the county was divided into four quadrants (See Figure 1). According to the Missouri Geological Survey Inventory of Mines, Occurrences, Prospects (IMOP) database the northeast (NE) quadrant has six mining sites, the northwest (NW) quadrant contains 12 mining sites, the southeast (SE) quadrant contains 42 mining sites, and the southwest (SW) quadrant contains 192 mining sites. Of these, 202 of the mining sites were designated for lead or lead and other commodities, particularly zinc and barite (commonly called tiff), while the remaining sites were exclusively for tiff mining. Besides the suspected mining sites, lead contaminated soil was hauled from farm fields in the Big River floodplain to numerous residences and businesses throughout Jefferson County for landscaping and fill purposes (See Figure 2). This public health assessment will not include the Doe Run smelter in Herculaneum that is being addressed by a separate Potentially Responsible Party (PRP) lead Remedial Action. (1)

The U.S. Environmental Protection Agency (EPA) proposed adding the Southwest Jefferson County Mining site to the National Priorities List (NPL) on April 9, 2009, and added it on September 23, 2009. The NPL is EPA's national list of the most seriously contaminated sites that are eligible for federal cleanup under CERCLA.

Mining activities began in Jefferson County in the early 1800s in the southern area, where Cambrian dolomite source rock is concentrated along the Big River and other major streams. Two mines were in operation as early as 1818: Gray's mine, located on the Big River, and McKane's mine located on Dry Creek. The Valles Mines site was also in operation around this time with its major mining operations running from approximately 1824 through the 1930's. Many other mines were opened in the 1830s and 1840s for the production of lead, zinc, and tiff. By 1855, smelters were operating in Jefferson County at Valles Mines, Mammoth Mines, and Sandy Mines. Historical records indicate that over three million pounds of lead was shipped out of Jefferson County annually during this time period. (1,2,3)

Site Investigations

Mining Related

Previous investigations in Jefferson County have focused on the greater Herculaneum area and the currently operating Doe Run Company smelter, and the Valles Mines area. As mentioned earlier, the Herculaneum site is being addressed under a PRP lead Remedial Action and will not be discussed in this public health assessment.

The Valles Mine area of the Southwest Jefferson County Mining site was investigated by the Missouri Department of Natural Resources (MDNR) in a PRE-CERCLIS Site Screening Report dated December 23, 2002, and in a Preliminary Assessment, Site Inspection, Removal Assessment Report dated March 31, 2005. The investigations found elevated levels of lead in surface soils, the remains of chat piles, sediment, surface water, and the abandoned railroad bed. Maximum levels of lead were found in surface soils in the vicinity of the smelter at 50,800 parts per million (ppm), in the centerline of the railroad bed at 14,300 ppm, and 3,900 ppm in the chat pile material. Two of the six private yards sampled in the vicinity of the site were found to have lead contamination slightly above EPA's time critical cleanup level of 1,200 ppm at a maximum of 1,320 ppm. (3,4)

In March 2007, Tetra Tech completed a Pre-CERCLIS Site Screening Assessment of the Jefferson County Lead site for EPA that determined the southwest quadrant was the area most impacted by past lead mining. Samples were taken from nine source areas (chat piles and mine tailings). Seven samples were analyzed with an x-ray fluorescence spectrometer (XRF) with lead levels ranging from 442 ppm to 7,070 ppm. Two of the source area samples were analyzed by EPA Region 7 laboratory with lead levels ranging from 1,190 ppm to 8,820 ppm. From the laboratory samples, the maximum level detected for cadmium was 159 ppm, 151,800 ppm for zinc, and for arsenic 28.1 ppm.

Five of the source areas are located in areas that have been developed for residential use.

(1)

Residential soil samples were also analyzed with an XRF. Of the 125 residential and school yards sampled, nine contained levels of lead above the Time-Critical Removal Action level of 1,200 ppm and 21 contained levels above EPA's secondary Non Time-Critical Removal Action of 400 ppm. None of the samples from school properties contained elevated levels of lead. Samples were also taken from 106 private drinking water wells of which twelve had lead levels above EPA's Safe Drinking Water Act Action Level of 15 parts per billion (ppb) and ranged from 15.7 ppb to 71.8 ppb. One of the wells had a cadmium level of 5.7 ppb, slightly above EPA's Maximum Contaminant Level (MCL) of 5 ppb for public drinking water systems. (1)

On May 7, 2008, Tetra Tech completed a Preliminary Assessment Report for the Jefferson County Lead Site for EPA that discussed EPA removal assessment sampling. As part of the assessment, soil was sampled from over 350 properties. Each residential yard was broken into quadrants (called cells) for sampling. Of these, 156 cells contained lead at 1,200 ppm or greater. About 200 soil samples were submitted to EPA's laboratory for analyses. Thirty nine of the samples contained lead above 400 ppm with 26 above 1,200 ppm. Soils were also analyzed for cadmium, barium, and arsenic. (1) Only a few soil samples exceeded ATSDR's Environmental Media Evaluation Guide (EMEG) arsenic and cadmium levels for a child. Four samples exceeded the EMEG for arsenic (20 ppm) with a maximum of 40.4 ppm while four also exceeded the EMEG for cadmium (10 ppm) with a maximum of 25.5 ppm. EMEGs are comparison values used to determine if a chemical is at a level needing further evaluation of the chemical and the exposure pathways. Levels below an EMEG are not expected to pose a health threat.

A total of 310 groundwater samples contained detectable concentrations of lead ranging from one to 94 ppb. One sample (sample # 3388-070) contained 3,070 ppb lead in water from a shallow well (80 feet deep). This well reportedly had not been in operation for an extended period of time, is not the primary drinking water well for the property, and the water sample had dirt in it (1,5). A total of 92 samples contained lead at concentrations above the Safe Drinking Water Act Action Level of 15 ppb. A total of 46 residential wells contained detectable barium ranging from 10.8 ppb to 1,640 ppb. The sample taken from well sample # 3388-070 had a barium level of 6,490 ppb, but was reported to have dirt in the water. Barium levels in all tested private wells, except well sample #3388-070, were below the MCL of 2,000 ppb. Cadmium was reported in 34 residential wells at concentrations ranging from 1.05 ppb to 21.1 ppb, with four wells above the MCL for cadmium of 5 ppb. Arsenic was only detected above its MCL of 10 ppb at 10.2 ppb in well sample # 3388-070. (1) See Table 1 for a summary of the contamination at the site.

Topsoil Related

In anticipation of purchasing clean replacement soil for remediating lead contaminated yards under the Time-Critical Removal Action, EPA sampled soil from a farm field in September 2006. The soil was found to contain lead ranging from 1,000 ppm to nearly

4,000 ppm. After correspondence with the land owner, it was discovered that soil from the farm had been hauled throughout the county for landscaping and fill by several trucking companies. In January 2007, EPA received a request from the Jefferson County Health Department to perform a soil removal action at the residence of a child with an elevated blood-lead level. Sampling determined that the soil was contaminated with lead at a maximum of 5,700 ppm. EPA obtained a list from the trucking company of approximately 100 locations where they had hauled the lead contaminated soil and began sampling soil at these locations. At the present time, the focus at the site is to remediate the yard soils contaminated with over 1,200 ppm of lead under a Time-Critical Removal Action to eliminate exposure to these elevated levels of lead. From early sampling at the site, approximately 22% of the yards tested contained levels of lead exceeding 400 ppm and roughly 6% had soil that exceeded 1,200 ppm of lead. Yards with soil levels less than 1,200 ppm, but above a calculated health risk level, are expected to be cleaned up under a future EPA Remedial Action. EPA often uses 400 ppm as a standard final action level, but may chose to calculate a different site-specific level as necessary.

Because the size of the site includes all of Jefferson County and the large number of yards and private wells contaminated with lead, the site was divided up into separate Operable Units (OUs) for the Time-Critical Removal Action. OU 00 (site wide) and OU 01 (historical mining residential soils) were combined into OU 00. The locations where the lead contaminated soil was transported and used for landscaping and fill became separate OUs and were designated as 02 and 03 (6,7,8).

OU-00: Site wide:

Mining Residential Soils: Includes mining sites, residential soils, and private wells that have been affected by mining or an unknown source of contamination. Remediation of residential soils with lead levels at 1,200 ppm and above is occurring under the Time-Critical Removal Action. The mining sites and yards with lead levels above a health risk level (Non Time-Critical Removal) are expected to be addressed by a future Remedial Action.

Summary Table of Residential Yards and Drinking Water Wells Activity in Operable Unit 00 as of June 30, 2011

Number of yards with lead levels above 1,200 ppm	172
Number of yards remediated	151
Number of private drinking water wells with lead levels above 15 ppb	38
Number of private drinking water wells with cadmium levels above 5 ppb	2
Number of residences offered temporary alternative water for drinking	40

ppm = parts per million

ppb = parts per billion

OU-02: Residential Soils: Soils with high concentrations of lead contamination delivered by a trucking company from a contaminated floodplain farm field to numerous residences and businesses throughout Jefferson County.

**Summary Table of Residential Yards Activity in
Operable Unit 02 as of June 30, 2011**

Number of yards with lead levels above 1,200 ppm	83
Number of yards remediated	76

OU-03: Residential Soils: Soils with high concentrations of lead contamination delivered by numerous trucking companies from a contaminated flood plain farm field to numerous residences and businesses throughout Jefferson County.

**Summary Table of Residential Yards Activity in
Operable Unit 03 as of June 30, 2011**

Number of yards with lead levels above 1,200 ppm	117
Number of yards remediated	113

As of June 30, 2011 EPA has remediated 340 residential yards and supplied an alternative source of drinking water to 40 well owners. EPA continues to sample residential yards and private drinking water wells. Yards with 1,200 ppm of lead and above are expected to be excavated and backfilled with clean soil (below 240 ppm of lead). Properties are prioritized by (1) households of pregnant women, (2) households with children 6 years old or less, and (3) households where children reside. Residents with contaminated private wells are offered bottled water as an alternative source of drinking water, but a study is being completed to determine if the installation of point-of-use filtration systems is a better alternative to providing uncontaminated drinking water. (6,7,8) Schools in Desoto, Festus, Hillsboro, along with schools in other areas have been sampled and remediated if lead levels were above guidelines (Personal conversation with Jim Silver, EPA's On-Scene Coordinator). Non time-critical yards are expected to be cleaned up under a future EPA Remedial Action.

On March 18, 2010 and March 30, 2011, DHSS personnel conducted a site inspection with EPA and MDNR to determine the present condition of the site and the activities that were occurring. We visited the different OUs and observed residences being remediated, past remedial actions, and areas to be remediated.

For the remaining residential yards/areas where the lead level is below 1,200 ppm, EPA is conducting a Remedial Investigation/Feasibility Study (RI/FS) and Human Health Risk Assessment to determine the best approach for remediation of these areas. As part of this

process, EPA will choose a final health-protective cleanup level for residential soil, either 400 ppm or another calculated site-specific number. A permanent solution to the contaminated private wells will also be part of the RI/FS. Because the area is so large, it will again be divided up into separate OUs. (9) For the RI/FS the OUs will be:

- OU-01: Historical Mining-Residential Soils
- OU-02: Lubbers hauled Residential Soils
- OU-03: Stewart Farm sold Residential Soils
- OU-04: Unconsolidated Mine Waste
- OU-05: Groundwater Wells
- OU-06: Valles Mines

Other Sources of Exposure to Contaminants

Lead exposure can occur from many sources, all of which are important to consider. One of the most important sources of lead exposure, especially for children under 72 months of age, is lead-based paint. A large percentage of homes in Jefferson County were built before 1979. Many of these homes have lead-based paint because its use in residential paint was not restricted until 1978. Lead pipes and/or lead based solder used on piping connections are other lead exposure routes that can be found in older homes. From the 2000 U.S. Census data, 55.4 % of Jefferson County homes were built before 1979 (10). The current percentage of older homes is expected to be lower since many new residences have been built since 2000. However, older homes may have deteriorating and cracking lead paint around areas of friction for example windows, where the lead-based paint is ground to dust. Young children can easily be exposed to lead contamination through their high hand-to-mouth activity when exposed to lead dust (11). Additional sources of lead exposure can be folk remedies, children toys, and improperly glazed pottery.

Jefferson County Health Department Activities

Prior to the Southwest Jefferson County Mining site being listed as an EPA National Priorities List site, elevated blood-lead levels were known to be a problem in Jefferson County. DHSS data show that in Jefferson County, 2% (333 children of an estimated population of 17,462) of the children less than 72 months of age had their blood lead tested in 1996. Of those tested, 8% (28 children) were found to have blood-lead levels above 10 microgram per deciliter ($\mu\text{g}/\text{dL}$).

In more recent data, the number of children whose blood-lead level was tested has increased. For the calendar year of 2008 in Jefferson County, 12% (2,001 children of an estimated population of 17,184) of the children less than 72 months of age had their blood lead tested. Of those tested, 1% (18 children) was found to have blood-lead levels above 10 $\mu\text{g}/\text{dL}$. Data for calendar year 2010 remains relatively unchanged with 12.3% (2109 children of an estimated population of 17,184) of the children less than 72 months

of age. Of those tested, 1% (14 children) was found to have blood-lead levels above 10 µg/dL. Factors that may have increased the blood-lead testing numbers and lowered the percentage of children over 10 µg/dL from the 1996 numbers are: increased provider (doctors, nurses, etc.) education, patient and community education about lead poisoning, increased effort by the Jefferson County Health Department (JCHD) to sample more children, and increased Medicaid funding and outreach for testing of children in low income families.

CDC previously considered 10 µg/dL or greater as the level that a child was considered to have an elevated blood-lead level. New information from CDC's Advisory Council on Childhood Lead Poisoning Prevention (ACCLPP) is that there is evidence that children's physical and mental development can be affected at blood-lead levels less than 10 µg/dL. CDC's new recommendation is that children identified with blood-lead levels greater the 5 µg/dL should prompt public health action as recommended by ACCLPP (12). Future public health actions at the site should account for this new recommendation.

Because of the elevated blood-lead levels in children in Jefferson County and elevated soil and groundwater lead levels found in MDNR and EPA investigations, EPA began a Time Critical Removal Action in approximately 2007. To inform the public of what was occurring and answer questions, EPA conducted two public meetings on October 21, 2008 and June 16, 2009. As part of the meeting, DHSS provided health educational materials, and in cooperation with ATSDR and JCHD, provided free blood-lead testing to anyone attending the meeting.

Elevated Blood Lead Risk Assessment

Currently, when the JCHD or a health care provider identifies a child with a blood lead level above 10 µg/dL, the child is said to have an elevated blood lead level. When a child is found to have an elevated blood lead level, their health care provider, local county health department, and/or managed health care agency typically provides health education to the family to reduce the child's blood lead level. For every child with a blood lead level above 15 µg/dL, an Elevated Blood Level Risk Assessment is completed to find the likely source of lead exposure. In Jefferson County, the county health department performs the risk assessments. The risk assessments typically include testing for lead in drinking water, yard soil, dust from soil, lead-based paint, or other interior sources such as doorways, windowsills, window troughs, walls, toys, along with other areas the child may come into contact with lead. JCHD offers blood lead testing for citizens of Jefferson County to determine if they have an elevated blood lead level. As discussed above, new CDC recommendations regarding blood-lead levels greater than 5 µg/dL should be accounted for in the future.

Land Use, Natural Resources, and Geology

Besides the larger municipalities (Arnold, Hillsboro, Desoto, Pevely, Festus, Crystal City, and Herculaneum) and smaller cities, the county is mostly rural with rolling hills and some agriculture. Residents may be located on single family rural acreage or large lots in major subdivisions, with some around lakes.

In the past, natural resources in Jefferson County included lead and barite deposits, mostly in the southwest portion of the county, that were mined but are now depleted or not economically profitable to mine. Presently, natural resources consist of forestland, wildlife, and water bodies, including tailings ponds that are sometimes used for fishing. Jefferson County lies on the margin of the Springfield-Salem Plateaus section of the Ozark Plateau physiographic province. Exposed bedrock units range in age from Cambrian to Pennsylvanian with the Cambrian unit being mostly massive dolomite. From these formations, lead, barium, and zinc ores were mined. These ore bodies occurred along the Big River and larger creeks in southern Jefferson County. (1)

Domestic groundwater wells draw their water from either alluvial (stream deposited material) or deep bedrock aquifers. The Ozark aquifer is the shallowest of the deep bedrock aquifer and varies between 200 to 835 feet in thickness. Beneath the Ozark aquifer is the St. Francois Confining unit that consists of a 325-foot thick layer of shale, fine-grained limestone, and dolomites. The confining unit is an effective barrier to downward groundwater movement. Beneath the confining unit lies the St. Francois aquifer. (1)

Physical Hazards

Physical hazards are present at some of the mining sites and may include old equipment, mining waste, concealed or open mine shafts, and the possibility of drop-off areas. Residential areas have few, if any, mining related physical hazards.

Demographics

According to the 2000 U.S. Census data, Jefferson County has a population of 198,099. See Figure 3 for a breakdown of the location of certain population groups. The population of Jefferson County is 97.5% white, 0.7% black or African American, 0.3% American Indian and Alaska Native, 0.4% Asian, 0.2% some other race, and 0.9% two or more races. The percentage of children under five is 7.2% with the percentage of adults over 65 years of age being 9.2%. The percentage of families below the poverty level in Jefferson County is 4.9% and the percentage of homes built before 1979 is 55.4%. (10)

Quality Assurance and Quality Control

Various people, organizations, and contractors have been involved in the sampling, research, and analyses at this site, resulting in Quality Assurance and Quality Control (QA/QC) information of varying degrees of accuracy and precision. In preparing this public health assessment, DHSS and ATSDR have relied on the information provided in the referenced documents and have assumed that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analysis and, therefore, the conclusions in this public health assessment are valid only if the referenced information is complete and reliable.

DISCUSSION

Pathway Analysis

This section addresses the pathways by which residents of the area may have been exposed to lead, and to a lesser degree, arsenic, cadmium, and barium from the contaminated tailings, soil, and/or groundwater. When a chemical is released into the environment, the release does not always result in exposure. Exposure only occurs when a chemical comes into contact with and/or enters the body. To determine whether the residents of Jefferson County were exposed to hazardous substances from the site, DHSS conducted an analysis of exposure pathways. For a chemical to pose a health risk, a completed exposure pathway must exist. ATSDR has determined that an exposure pathway consists of five elements, including: a source of contamination, transport through an environmental medium such as soil or water, a point of exposure, a route of human exposure, and a receptor population. Completed exposure pathways require that all five of the elements of exposure exist. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Potential exposure pathways, however, have at least one of the five elements missing or uncertain, but all five elements could exist. Completed and potential exposure pathways could have occurred in the past, could be occurring presently, or could occur in the future. Exposure to lead at this site is through the ingestion or inhalation of lead-contaminated tailings/soil that have been placed on the land surface or moved where humans can come into contact with them, or ingestion of contaminated groundwater. Dermal contact is not considered a pathway of exposure, because lead is not readily absorbed through the skin.

Completed Exposure Pathways

Lead has been found to be the main contaminant at the Southwest Jefferson County Mining site and has contributed to elevated blood-lead levels in children less than 72 months of age. The five elements of a completed exposure pathway at the Southwest Jefferson County Mining site are:

1. **Contaminant source** – lead contaminated tailings, soils, and groundwater.
2. **Environmental medium and transport** – soil, groundwater, dust, surface water, sediment, fish, air, and garden vegetables.
3. **Point of exposure** – areas where exposure to lead contamination is taking place.
4. **Route of exposure** – ingestion and inhalation.
5. **Receptor population** – those that ingest and/or inhale lead contamination.

Completed Exposure Pathways

Completed exposure pathways at the Southwest Jefferson County Mining site have existed in the past, are presently occurring, and will continue in the future, until the exposure to lead in soil and groundwater are reduced or eliminated. See Table 2 for a list of exposure pathways. Lead is the primary contaminant and, to a lesser extent, arsenic and cadmium. The major exposure pathways are ingestion and to a lesser extent inhalation of lead and other contaminants.

Exposure to soil contaminants can occur by directly or accidentally ingesting the soil while working, playing, gardening, or spending time in the yard. This contaminated soil can be tracked indoors by shoes, pets, and other methods and accumulate in the home. Individuals, especially children, can accidentally ingest this contaminated dirt in the home. Children are more likely to be exposed to household dust and other forms of contaminated media because of their high hand-to-mouth activity (11). Although it is a minor route of exposure, individuals can also be exposed by inhalation of contaminated dust in the yard and contaminated dust in the home. When this soil or dust is stirred up and becomes airborne, individuals, especially children, may breathe it in and then clear it from their lungs and swallow it. Lead is not readily absorbed through the skin, so dermal contact with lead contaminated soil is not an important route of exposure.

Individuals can be exposed to the lead in their water supply through ingestion while drinking and cooking with contaminated water. Individuals may accidentally ingest lead contaminated water while bathing, playing, or swimming. Dermal contact to lead in water is not an important route of exposure.

In addition to exposure to soil and groundwater, the DHSS Childhood Lead Program along with the Jefferson County Health Department have identified children in the area with elevated blood lead levels whose homes had elevated levels of lead in indoor dust. The high levels of lead in the indoor dust may have come from elevated levels of lead in outdoor soil, dust from lead based paint in the home, or other sources. This completes an exposure pathway through ingestion and to a lesser extent inhalation of lead contaminated indoor dust. Areas with contaminated soil of 1,200 ppm of lead and above are being addressed as part of EPA's Time Critical Removal Action, but they may not be granted access to sample and remove contaminated soil at all residences.

Potential Exposure Pathways

Potential exposure pathways consist mostly of those areas where the environment has not been tested for lead contamination. These include the water bodies associated with past disturbed mining areas and the streams that run through the site. Limited sampling has found that levels of lead are present in the surface water and sediment, with cadmium and zinc being present at certain locations in the sediment above levels of health concern. Fish in these water bodies have not been tested to see if they contain lead at a level of health concern. Certain garden produce (such as leafy plants) grown in lead contaminated soil or wild edible plants growing in mining disturbed soils could be a potential source of exposure. Other plants, such as root crops that are not washed properly could also be an exposure pathway. Exposures to these potential pathways may or may not be at a level of health concern.

TOXICOLOGICAL EVALUATION

Introduction

This section will discuss the health effects of exposure to specific contaminants found at the site. A discussion of non-cancerous health effects and the possibility of the contaminants causing cancer are evaluated in this section. ATSDR has developed Comparison Values (CVs) that are media-specific concentrations used by health assessors to select environmental contaminants of concern. Contaminant concentrations that are less than the CV are unlikely to pose a health threat. Contamination levels above the CV do not necessarily indicate that a health threat is present, but that further evaluation of the chemical and pathways is needed. CVs are usually developed for chronic exposure (more than 365 days), intermediate exposure (14 day to 365 days) and acute exposure (less than 14 days). Environmental Media Evaluation Guides (EMEGs) are media-specific CVs that have been derived for a variety of chemicals including arsenic, cadmium, and barium.

As there is no known safe level of exposure to lead, ATSDR has not developed a CV for lead. Instead, exposure to lead is evaluated by using an EPA biological model that predicts a blood lead concentration that would result from exposure to lead levels found in the environment.

Lead, and to a lesser extent arsenic, barium, and cadmium have been found in tailings piles, soils, and groundwater in mostly the southwest portion of Jefferson County. In addition, lead contaminated soil has been hauled to residential areas throughout the rest of the county. The tailings areas and residential yards vary as to the amount of exposure that occurs in each area. Although lead is naturally occurring, the practice of depositing mine tailings above ground has made a large volume of lead more accessible to people. From natural processes and human activities, the contaminated tailings and soil have been moved throughout the community in different media where exposures occur.

Lead

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It is mined and processed for use in various industries. It is used in some types of batteries, ammunition, ceramic glazes, medical equipment, scientific equipment, and military equipment. At one time, lead was used as an additive in gasoline and paint (12). Paint containing lead may still be present in older homes and becomes more available for uptake into the body if it is deteriorated or flaking. Tailings contaminated with lead have been deposited on the ground surface in tailings piles and also moved by nature and man into areas where exposure can easily occur. Lead contaminated soils have also been hauled to use as landscaping in other parts of Jefferson County.

The pathways of concern for lead exposure are ingestion and to a lesser extent inhalation. Lead is not readily absorbed through the skin, so dermal contact is not an important route of exposure. The correlation between lead-contaminated soil and blood lead level are influenced by many factors, including access to soil, levels of lead in soil, behavior patterns (especially of children), presence of ground cover, seasonal variation of exposure conditions, particle size and composition of lead compounds found at various sites, and the route of exposure (14). These complex factors explain in some instances the discrepant findings that are reported in the literature (15).

Children are more sensitive to the effects of lead than adults. The Centers for Disease Control and Prevention (CDC) considers lead poisoning the number one preventable health problem facing children (11). No safe blood-lead level (BLL) in children has been determined. Until recently, children were identified as having a blood-lead level of concern if the test result was 10 µg/dL or greater of lead in the blood. Studies have shown that adverse health effects can also occur in children with blood-lead levels below 10 µg/dL (11,13). CDC recently began using a reference level of 5 µg/dL, the 97.5 percentile of blood lead in a representative sample of children in the U.S. 1-5 years of age. In other words, 2.5% of these children had blood lead levels at or above 5 µg/dL. Children identified with BLL greater than or equal to 5 µg/dL should prompt public health actions as recommended in the report of the Advisory Committee on Childhood Lead Poisoning Prevention: *Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention* (January 4, 2012). Health effects of lead poisoning at these BLLs include decreased attention span, hyperactivity, and lower IQ scores. Needleman and Gatsonis report that children's IQ scores are inversely related to blood lead levels. Several studies provide sufficient evidence that children's mental process or the faculty by which knowledge is acquired was adversely affected by lead (15).

Lead has no nutritional benefits for humans and has its greatest effect on the nervous system, especially in children. An unborn child can also be exposed to lead if their mothers have lead levels in their bodies. This exposure can cause problems such as premature births, low birth weight, decreased mental ability, learning difficulties, and reduced growth as young children. Young children can also be exposed to lead in their mother's breast milk if she has elevated lead levels in her system (13).

The biologic fate of inorganic lead in the human body is well known. Inorganic lead is not metabolized but is directly absorbed, distributed, and excreted. Once in the blood, lead is disturbed primarily among three compartments -- blood, soft tissue (kidney, bone marrow, liver, and brain), and mineralizing tissue (bones and teeth). Mineralizing tissue contains about 95% of the total body burden of lead in adults (13).

The lead concentrations found in the soil and well water in Jefferson County exceed site-specific EPA action levels. Residents, especially children, who are exposed to lead contaminated soil and well water, may be at risk for adverse health effects. To alleviate these exposure pathways, EPA is remediating lead contaminated residential soils and providing bottled water under a Time-Critical Removal Action. A future Remedial Action will address those residences in the Non Time-Critical Removal Action range of lead contamination.

Arsenic

Arsenic is an element that is widely distributed in the earth's crust. Inorganic arsenic occurs naturally in soils and many kinds of rock, especially in minerals and ores that contain copper and lead. Inorganic arsenic is expected to be the form present at the site. Arsenic cannot be destroyed in the environment; however, it can change its form or become attached or separated from particles. It can change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the action of bacteria that live in soil or sediment. (16)

The pathways of uptake for arsenic at the site are ingestion and to a lesser extent inhalation. Arsenic contaminated soil or water on the skin is a minor pathway at this site; however direct skin contact with high concentrations of inorganic arsenic compounds may cause the skin to become irritated, with some redness and swelling. It does not appear that skin contact is likely to lead to any serious internal effects. Skin exposure to the low levels of arsenic in the soil at this site is not a concern. After ingestion or inhalation exposure to arsenic, the liver changes some of the arsenic to a less harmful organic form, which is excreted in the urine. Most of the arsenic will be gone within several days after exposure stops, but some will remain in the body for several months or longer. Inorganic arsenic has been recognized as a human poison since ancient times, and large oral doses (above 60 ppm in food or water) can produce death. Smaller doses of inorganic arsenic (0.3 to 30 ppm in food or water) may cause irritation of your stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea. Other effects from ingestion of inorganic arsenic include decreased production of red and white blood cells which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needle" sensation in the hands and feet. (16)

ATSDR has developed an EMEG for arsenic in soil of 20 ppm for children and 200 ppm for adults for chronic exposure (greater than 365 days). ATSDR has also developed an acute value (less than 14 days) of 10 ppm for the pica child (16).

A soil sample of one quadrant from each of 175 individual properties was analyzed for arsenic by the EPA's Region 7 laboratory as part of the EPA Removal Assessment. The level of arsenic in these soil samples ranged from 1.14 ppm to 40.4 ppm. Of the 175 samples taken, only four contained arsenic above the EMEG for children of 20 ppm (1). The data show that arsenic concentrations in soil appear sporadic and unrelated to lead concentrations. Although health concerns are unknown, exposure to elevated levels of arsenic could still be occurring in portions of these residential yards. EPA's removal of the lead contaminated soil will also address any arsenic contamination, and the possibility of exposure, in yards co-located with elevated lead levels. Any remaining elevated arsenic contamination should be considered in future remedial actions at the site.

Source areas contain higher levels of arsenic that would allow for greater exposure. However, the time spent in the source areas is expected to be limited with only short-term exposure.

Of the 310 groundwater samples taken as part of the EPA Removal Assessment, only well sample # 3388-070 tested above the MCL for arsenic. This well contained arsenic at a level of 10.2 ppb, slightly above the MCL of 10 ppb. The well is one of four on the property, is reported to not been in operation for an extended period of time, and is not the primary drinking water well for the property.

Barium

Barium is a silvery-white metal that is found in barite ores containing mixtures of elements. When combined with other chemicals such as sulfur or oxygen, it forms barium compounds. These compounds are used to make paint, bricks, ceramics, glass, rubber, and other products. Barium compounds are also used by the oil and gas industries to make drilling mud that makes it easier to drill through rock by keeping the drill bit lubricated. (17)

The health effects of the different barium compounds vary depending on how well the compound dissolves in water or in the stomach. Barium compounds that do not dissolve well, such as barium sulfate, are generally not harmful. In fact, doctors sometimes use barium sulfate when performing some medical tests and taking x-rays of the gastrointestinal tract. (17)

Barium is sometimes found naturally in drinking water and food. The barium compounds that are usually found naturally do not dissolve or mix well with water, so the amount of barium found occurring in drinking water naturally is usually small. Certain foods, such as Brazil nuts, seaweed, fish, and some plants, may contain high concentrations of barium, but the concentration is not usually enough to be a health concern. (17)

Barium concentrations in residential yards ranged from 74 to 3,500 ppm, which are below the ATSDR's chronic EMEG for a child (10,000 ppm). A total of 46 residences had levels of barium in their wells above 1,000 ppb, but only a single well contained

barium above its MCL of 2,000 ppb in laboratory analyses. Again, this is the same shallow well (sample # 3388-070) that contained elevated levels of other contaminants. Barium was detected slightly above health guidelines in only this one instance.

Since levels of barium are below health guidelines, except for one well that is unlikely to be used as a source for potable water, no health effects are expected from the exposure to barium.

Cadmium

Cadmium is a soft, silver-white metal that occurs naturally in the earth's crust. Cadmium is not usually present in the environment as a pure metal, but as a mineral combined with other elements. It is most often present in nature as complex oxides, sulfides, and carbonates in zinc, lead, and copper ores. Cadmium has many industrial uses and is used in consumer products including batteries, pigments, metal coatings, plastics, and some metal alloys. (18)

The exposure route of concern for cadmium in Jefferson County is ingestion of contaminated drinking water. Low levels of cadmium are present in most foods with the highest levels present in shellfish, liver, and kidney meats. Cigarette smoke also contains cadmium and can double the daily intake. Ingestion of high levels of cadmium in contaminated food or water can severely irritate the stomach, leading to vomiting and diarrhea, and sometimes death. Cadmium is a cumulative toxicant and ingestion of lower levels for a long period of time can lead to a buildup of cadmium in the kidneys and, possibly, kidney damage. The kidney is the main target organ for cadmium toxicity following chronic-duration exposure by oral routes. The EPA has classified cadmium as a probable human carcinogen by inhalation based on limited evidence of an increase in lung cancer in humans from occupational exposure to cadmium fumes and dust and evidence of lung cancer in rats. Studies on humans and animals ingesting cadmium have not found increases in cancer, although additional research is needed. (18)

Two private wells were found to have cadmium levels slightly above the MCL for cadmium (maximum of 5.69 ppb vs. MCL of 5 ppb) and the single well sample # 3388-070 that had an estimated concentration of 11.8 ppb. Considering that cadmium was detected only slightly above its MCL in a few private wells, no adverse health effects are expected, especially since EPA has offered bottled water to these households to eliminate exposure.

Of the 175 soil samples that were analyzed in the laboratory for cadmium, only four exceeded ATSDR's Chronic EMEG for a child of 10 ppm, but did not exceed the EMEG for an adult of 100 ppm. The maximum detected in the four samples that exceeded the EMEG was 25.5 ppm. Since only four soil samples exceeded the cadmium EMEG for a child and these yards also have elevated levels of lead contamination, these yards should be remediated by EPA eliminating exposure pathways and health concerns.

Cancer

The American Cancer Society estimates that in the United States, slightly less than half of all men and slightly more than one-third of all women will develop some form of cancer in their lifetime (19).

While the EPA considers lead to be a probable human carcinogen and the National Toxicology Program (NTP) has determined that lead and lead compounds are reasonably anticipated to be human carcinogens based on limited studies (14,20) there has been no studies linking residential ingestion or inhalation of lead contaminated soil or drinking water to increased cancer risks. The primary health concern for lead at the Southwest Jefferson County Mining site is not cancer, but lead's effect on the nervous system, especially for children less than 72 months of age.

Arsenic is considered by EPA, the International Agency for Research on Cancer, and the NTP to be a human carcinogen by the inhalation and ingestion exposure routes. Exposure by the inhalation route in workers has shown the predominant carcinogenic effect is increased risk of lung cancer. In general, most researchers observe that risk increases as a function of exposure and duration. Most of the research on arsenic causing lung cancer comes from studies involving workers at copper smelters and arsenical chemical plants. When exposure occurs by the ingestion route, the main carcinogenic effect is increased risk of skin cancer. This is based on epidemiological studies of populations exposed to levels of arsenic in drinking water. Other studies have shown that inorganic arsenic can also increase the risk of bladder, liver, kidney, and prostate cancer (16). Since arsenic was detected above its MCL in only one well that is not expected to be used for human consumption, carcinogenic health effects are not expected.

Barium has not been shown to cause cancer in humans. The EPA has determined that barium is not likely to be carcinogenic to humans following ingestion and that there is insufficient information to determine whether it will be carcinogenic to humans following inhalation exposure. (17)

Cadmium is considered a probable human carcinogen (limited human, sufficient animal studies) from inhalation by EPA and a known human carcinogen by NTP. An association has been found between occupational inhalation exposure to cadmium and lung cancer (18). Although no air sampling has been done in Jefferson County, concentrations of cadmium are not expected to be anywhere near occupational levels, and no carcinogenic health effects are expected.

Mixtures

Lead is the major contaminant of concern at this site and has no nutritional value for humans. Although lead's greatest damaging effect on the human body is to the nervous system, it also can damage the kidneys with exposure to high levels. Cadmium can also affect the kidneys after long-term exposure to low levels. Although both lead and cadmium can affect the kidneys, given the low levels of exposures, no synergistic health

impacts are expected. The synergistic effect is exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The cleanup of contaminated residential yards and providing an alternative drinking water source for contaminated private wells by EPA should further reduce any exposure.

Children's Health Considerations

In general, children are more likely than adults to be exposed to contaminants in soil and water. In their daily activities, children have a tendency for frequent hand-to-mouth contact and often introduce non-food items into their mouths. Children who exhibit pica behavior are even more likely to consume larger amounts of non-food items. A pica child has a craving to put non-food items in their mouths or eat non-food items, such as dirt, paint chips, etc. Because children are smaller, their bodies/organ systems are still developing, and they typically absorb more of the contaminants, so it usually takes less of a contaminant to cause adverse health effects in children than adults (13).

Children are more susceptible to lead poisoning than adults, and children are also more likely to be exposed to lead contaminated materials. Infants and young children can swallow and breathe lead in dirt, dust, or sand while they play on the floor or ground. They can also be exposed to lead through breast milk if the mother has elevated levels of lead in her system. Also, compared to adults, a larger proportion of the amount of lead swallowed will enter the blood in children (13). While about 99% of the amount of lead taken into the body of an adult will leave as waste within a few weeks, only about 32% of lead taken into the body of a child will leave as waste (13). All of these factors result in children being more affected by lead than adults when they have similar lead concentrations in their environment.

When children are exposed to lead contaminated materials, a variety of adverse health effects can occur depending on the level of lead to which they are exposed and the duration of exposure. These effects include learning disabilities, slowed growth, hyperactivity, impaired hearing, and at very high exposure levels, even brain damage. Unborn children can also be exposed to lead through their mothers if their bodies contain lead and are at risk of premature birth, low birth weight, decreased mental ability, learning difficulties, and reduced growth as young children (13).

Children who exhibit pica behavior may be at an even greater risk of exposure to contaminants in soil than other children. Individuals who exhibit pica behaviors have a craving to put non-food items in their mouths or eat non-food items, such as dirt, paint chips, etc (13).

CDC's previously considered 10 micrograms of lead per deciliter of blood ($10 \mu\text{g/dL}$) as the level of concern; however, studies have shown that adverse health effects can also occur in children with blood-lead levels below $10 \mu\text{g/dL}$ (11,14). In 2012, CDC adopted the recommendation by the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) to begin using a "reference value" that is based on the population of children aged 1-5 years in the U.S. whose blood lead levels are in the highest 2.5% of

children tested. That level is currently 5 µg/dL of blood (12). Yearly blood-lead testing before a child is 72 months of age is key to determining if the child has been exposed. Eliminating exposure pathways by controlling contamination sources, practicing good personal hygiene, and eating a proper diet high in calcium can lessen the risk of lead poisoning (11).

COMMUNITY HEALTH CONCERNS

Community health concerns vary considerably around the site. If residents have agreed to have their property sampled and their yard is affected by the contamination, they are generally concerned and want the property cleaned up. However, some residents will not permit their property to be sampled, and they and their families may continue to be exposed to the lead contamination. To prevent lead contaminated soil from continuing to be sold for landscaping, the county commission is considering a regulation that soil must be sampled and confirmed clean.

A Public Comment Version of the Southwest Jefferson County Public Health Assessment was available for public comments from March 16, 2011 to May 16, 2011. On May 5, 2011, DHSS held a public availability session to present the public comment version and gather and discuss any concerns the public might have. Personnel from MDNR and EPA were also available at the meeting to answer any environmental concerns. No health concerns or environmental questions were presented in person or received by mail or email.

The public comment period for the Southwest Jefferson County Public Health Assessment was extended until June 10, 2011, because of elected officials/resident requests. No comments were received.

CONCLUSIONS

CONCLUSIONS

DHSS has reached four important conclusions in this health assessment:

Conclusion 1

Mining Related Soil

Ingesting (swallowing) and to a lesser extent inhaling (breathing) lead contaminated soil or dust for a year or longer at levels found in many of the residential yards within the Southwest Jefferson County Mining site may harm individuals' health. This conclusion applies to past, present, and future exposure to lead at this site.

Basis for Decision

Residential yards throughout the mining areas in the Southwest Jefferson County Mining site contain lead and infrequently arsenic and cadmium in soil at concentrations above a level of health concern. The primary concern from exposure to lead in Jefferson County is the effects lead has on the nervous system, especially on children less than 72 months of age.

EPA has removed soil from numerous residential yards with lead concentrations above EPA's Time-Critical Removal Action level. These yards contained soil with lead contamination at a concentration of 1,200 parts per million (ppm) and greater or lead concentrations of 400 ppm and above for those homes with a child less than 72 months of age with an elevated blood lead level.

Some residential yards with soil containing lead above EPA's Time-Critical Removal Action level, and numerous residential yards with soil containing lead at concentrations above EPA's standard health risk level of 400 ppm still remain. A future EPA Remedial Action is expected to clean up these yards where access can be gained. Exposure to the soil in these yards for a year or longer may harm people's health. Individuals, especially young children, can be exposed to this contaminated soil directly by accidentally ingesting the soil while playing or spending time in the yard. Contaminated soil can also be tracked indoors by shoes and pets and subsequently accumulate in the home. Young children, can accidentally ingest contaminated floor and windowsill lead containing dust in the home. Although it is a minor route of exposure, individuals can also be exposed by inhalation of contaminated dust in the yard and contaminated dust in the home. When this soil or dust is stirred up and becomes airborne, individuals, especially children, may breathe it in and then clear it from their lungs and swallow it.

All lead exposure sources are important to consider, as lead-based paint or other non-site related sources of lead along with non-traditional sources, such as folk remedies, may add to these concerns.

Conclusion 2
Hauled in soil

Ingesting and to a lesser extent inhaling lead contaminated soil or dust for a year or longer from residential yards where lead-contaminated topsoil was hauled in may harm individuals' health, especially children less than 72 months of age. This conclusion applies to past, present, and future exposure to lead in these yards.

Basis for Decision

Residential yards throughout Jefferson County have been contaminated with lead contaminated soil that has been hauled from areas on the Big River floodplain to residential locations where it was used for landscaping and fill purposes. The primary concern for exposure to lead from these yards is the effects lead has on the nervous system, especially on children less than 72 months of age.

EPA is removing soil from residential yards with lead concentrations above EPA's Time-Critical Removal Action level. A future EPA Remedial Action is expected to clean up the soils with lead contamination above a health risk level in yards where access is allowed. For detailed removal information, see conclusion 1.

All lead exposure sources are important to consider, so lead-based paint or other non-site related sources of lead can add to these concerns.

Conclusion 3
Groundwater

For past, present, and future exposures to lead and, to a lesser extent cadmium, residents can be exposed via drinking untreated well water for a year or longer that can harm their health.

Basis for Decision

A number of private drinking water wells in the Southwest Jefferson County Mining site contained lead at concentrations greater than 15 parts per billion (ppb) or cadmium above 5 ppb. The primary exposure route to lead or cadmium contaminated water is through ingestion. The primary concern from exposure to lead is the effect lead has on the nervous system, especially on children less than 72 months of age. All lead exposure sources are important to consider, so lead-based paint or other non-site related sources of lead can add to these concerns. Long-term exposure to low levels of cadmium leads to a buildup of cadmium in the

kidneys and possible kidney disease as well as lung damage and fragile bones.

EPA is currently using 15 ppb of lead and 5 ppb for cadmium as the site-specific action level for private well water in the Southwest Jefferson County Mining site as a guideline for providing temporary alternative sources of drinking water. For present and future exposures, those individuals who are using EPA provided temporary alternative sources of drinking water are no longer being exposed to contaminated water through ingestion.

For individuals who have refused EPA temporary alternative source of drinking water, they may still be drinking water from a contaminated private well. If these individuals are not drinking water from an alternative source or are not effectively filtering their well water, they may continue to be exposed to contaminants at levels that may harm their health.

Conclusion 4

DHSS cannot currently conclude whether exposure to lead through air, sediment, floodplain soils, surface water, fish, and edible plants in the Southwest Jefferson County Mining site could harm, or may have harmed individuals' health. Physical hazards are also expected to exist in the past mining areas. Information needed to make a decision is very limited.

Basis for Decision

Area water bodies (streams and lakes), sediment, floodplain soils, and fish have not been sufficiently tested in the Southwest Jefferson County Mining site area to determine whether they contain elevated levels of contaminants or if physical hazards are present to cause injury. More testing and investigation is needed to determine whether they may harm individuals' health.

RECOMMENDATIONS

1. EPA should continue to investigate residential yards, including newly developed residential properties, and other areas where individuals, especially children and expectant mothers, might be exposed to elevated lead and possibly other contaminants like arsenic and cadmium, and remediate appropriately.
2. EPA should continue to identify and sample private wells in the area to determine levels of lead and possibly other contaminants, like arsenic and cadmium, and take permanent actions to prevent exposure to drinking water with elevated levels of contaminants.
3. EPA/MDNR should continue and extend their sampling to other areas throughout Jefferson County where contamination may exist from past mining activities or the transport of lead contaminated soil and eliminate physical hazards left from past mining processes when found. EPA/MDNR should also include testing for other potentially mining related contaminants, such as arsenic, to determine if other contaminants may impact public health and require future actions.
4. Jefferson County Health Department/DHSS should continue their efforts to test the blood lead levels of children in the community and follow-up on children with elevated blood lead levels as necessary.
5. Jefferson County Health Department/DHSS should continue their efforts in reaching out to the community to educate them on the adverse health effects of lead exposure, stressing the importance of preventing lead exposures.
6. Indoor dust within a home may contain lead from a variety of sources, including lead based paint. Therefore, all agencies involved in remediation efforts in Jefferson County should work toward educating the public on how to reduce or eliminate their exposure to all sources of lead, including lead-based paint.
7. EPA/MDNR should sample other media, such as air, sediment, surface water, fish, and edible plants, so it can be determined if exposure to lead in these media can harm people's health.
8. Before developing property previously disturbed by mining, people should make sure that the property is tested for lead and other mining-related contaminants.
9. EPA and Jefferson County should continue their efforts to ensure that lead-contaminated soils are not being hauled throughout the county for landscaping and fill.

PUBLIC HEALTH ACTION PLAN

This Public Health Action Plan (PHAP) for the Southwest Jefferson County Mining site contains a description of actions by the Missouri Department of Health and Senior Services (DHSS), the Agency for Toxic Substances and Disease Registry (ATSDR), and other stakeholders. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and future exposures to hazardous substances at or near the site. Below is a list of commitments of public health actions by DHSS, ATSDR, or other site stakeholders:

1. DHSS/ATSDR will work with the Jefferson County Health Department to provide health education and blood lead screening for the residents of Jefferson County so they can reduce or eliminate their exposure to all sources of lead.
2. DHSS/ATSDR will continue to coordinate with the Jefferson County Health Department, MDNR, and EPA to provide necessary community health education to the public and health professionals and address community health concerns and questions that may arise.
3. DHSS/ATSDR will work with the Jefferson County Health Department to promote prevention of lead exposure from all sources and encourage residents of Jefferson County to have yearly blood lead testing of children less than 72 months of age and expectant mothers.
4. DHSS/ATSDR will work with the Jefferson County Health Department to encourage residents of Jefferson County to have their yards soils and private drinking water wells tested for lead and cadmium and remediated when they are found elevated.
5. DHSS/ATSDR will coordinate with the Jefferson County Health Department, MDNR, and EPA to implement the recommendations in this public health assessment.
6. DHSS/ATSDR will review additional sampling data from further investigations and provide guidance regarding possible health risk as needed.
7. DHSS/ATSDR will update this public health assessment as needed.
8. DHSS/ATSDR will assist EPA and Jefferson County officials, as appropriate, in their efforts to draft an ordinance prohibiting the selling of lead contaminated soil for landscaping and fill.

REPORT PREPARATION

This Public Health Assessment for the Southwest Jefferson County Mining Site was prepared by the Missouri Department of Health and Senior Services (DHSS) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

Author

Arthur Busch
Environmental Specialist
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

State Reviewers

Jonathan Garoutte
Environmental Specialist
Bureau of Environmental Epidemiology
Missouri Department of Health and Senior Services

ATSDR Reviewers

Technical Project Officer
Alan Parham
Cooperative Agreement Team
ATSDR/DHAC/CAPEB

REFERENCES

1. Tetra Tech EM, Inc. Preliminary Assessment Report, Jefferson County Lead Site, CERCLIS I.D. # MON000705443. Jefferson County, Missouri for the U.S. Environmental Protection Agency. 2008 May 7.
2. Agency for Toxic Substances and Disease Registry. Valles Mine, Valles Mines School Road Health Consultation, Jefferson County, Missouri. EPA Facility ID: MON000704446. Atlanta: US Department of Health and Human Services. 2005 October 4.
3. Missouri Department of Natural Resources. Valles Mines Company Site, Jefferson County, Missouri, PRE-CERCLIS Screening Report. 2002 December 23.
4. Missouri Department of Natural Resources. Valles Mines Company Site, Jefferson County, Missouri, Preliminary Assessment, Site Inspection, Removal Assessment Report. EPA Facility ID: MON000704446. 2005 March 31.
5. Tetra Tech EM Inc. Pre-CERCLIS Site Screening Assessment, Jefferson County Lead Site, CERCLIS ID No. MON000705443. Jefferson County, Missouri, for the U.S. Environmental Protection Agency. 2007 July 25.
6. U.S. Environmental Protection Agency. On-Scene Coordinator Time-Critical – Removal Action (POLREP) # 13 on-going activities, Jefferson County Lead Site OU-00, Desoto Missouri. 2011 June 30.
7. U.S. Environmental Protection Agency. On-Scene Coordinator Time-Critical – Removal Action (POLREP) # 13 on-going activities, Jefferson County Lead OU-3, Desoto, Missouri, EPA Region VII. 2011 June 30.
8. U.S. Environmental Protection Agency. On-Scene Coordinator Time-Critical – Removal Action (POLREP) # 13 on-going activities, Jefferson County Lead OU-2, Desoto, Missouri, EPA Region VII. 2011 June 30.
9. U.S. Environmental Protection Agency. Superfund Information Systems: Site Progress Profile. Operable Units (OUS) at Southwest Jefferson County Mining (MON000705443). Updated 2011 May 19.
10. U.S. Census Bureau, Census 2000, Table DP-1 through DP-4. Profile of General Characteristics: 2000. Jefferson County, Missouri. 2000.

11. Center for Disease Control and Prevention. Preventing Lead Poisoning in Young Children. Atlanta: US Department of Health and Human Services. 2005 August.
12. Center for Disease Control and Prevention. CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "*Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention*". 2012 May 16.
13. Agency for Toxic Substances and Disease Registry. Toxicological profile for lead, update. Atlanta: US Department of Health and Human Services. 2007 August.
14. US Environmental Protection Agency. Superfund Lead-Contaminated Residential Sites Handbook. 2003 August.
15. Agency for Toxic Substances and Disease Registry. Analysis Paper: Impact of Lead-Contaminated Soil on Public Health. Atlanta: US Department of Health and Human Services; 1992 May.
16. Agency for Toxic Substances and Disease Registry. Toxicological profile for arsenic, update. Atlanta: US Department of Health and Human Services. 2007 August.
17. Agency for Toxic Substances and Disease Registry. Toxicological profile for barium, update. Atlanta: US Department of Health and Human Services. 2007 August.
18. Agency for Toxic Substances and Disease Registry. Toxicological profile for cadmium, update. Atlanta: US Department of Health and Human Services. 1999 July.
19. American Cancer Society. Cancer facts and figures, 2007. Atlanta: American Cancer Society, Inc; 2007.
20. National Toxicology Program. Lead (CAS No. 7439-92-1) and Lead Compounds Substance Profiles. Report on Carcinogens, Eleventh Edition; 2004.

APPENDICES

Appendix A:

- Figure 1: Jefferson County Site Location Map with Mining Sites
- Figure 2: Jefferson County Site Map with Elevated Residential Soils, 2008
- Figure 3: Jefferson County Site Location and Demographic Statistics

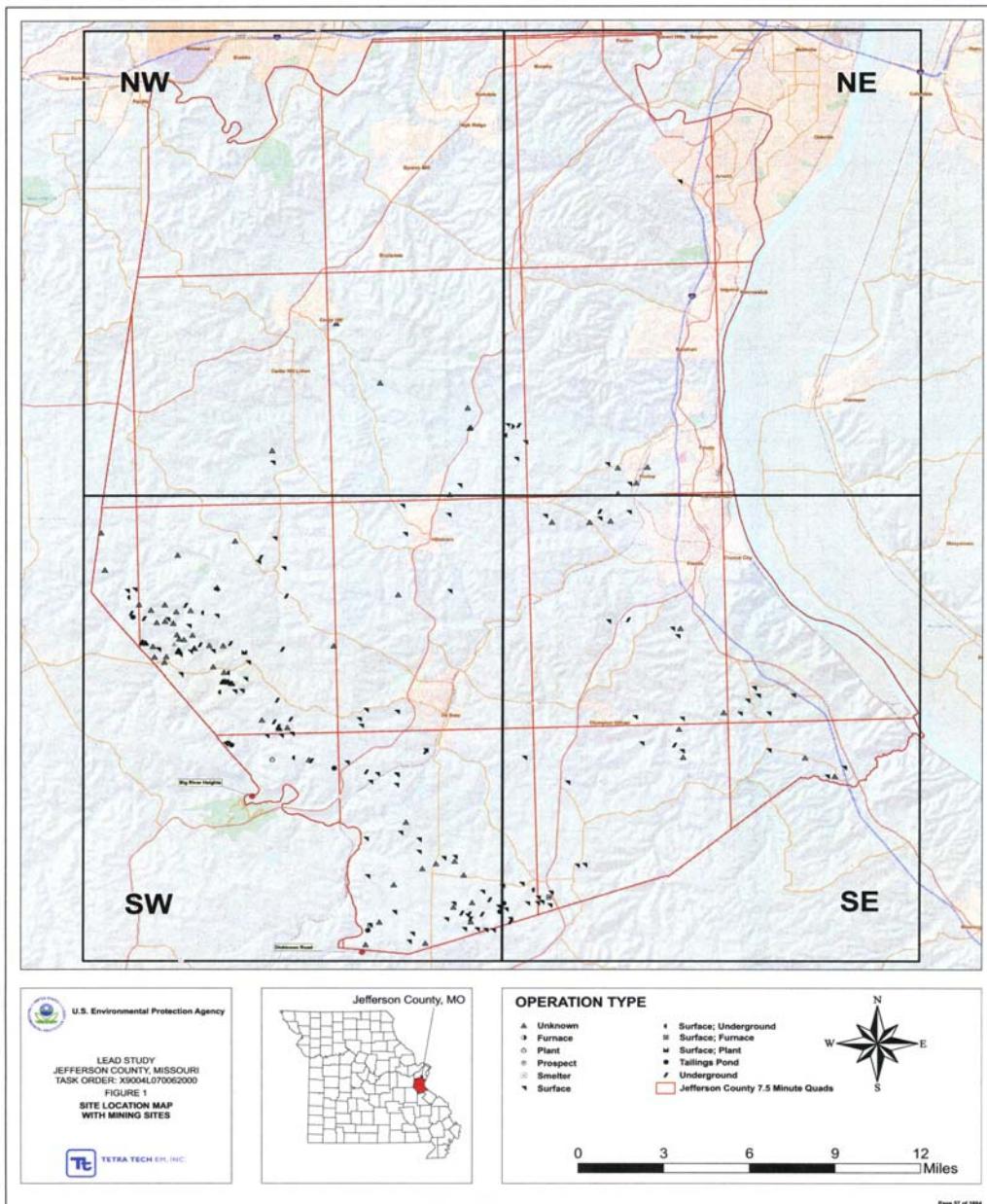
Appendix B:

- Table 1: Summary of Contaminants in the Southwest Jefferson County Mining Site and Health Guidelines
- Table 2: Southwest Jefferson County Mining Site Exposure Pathways

Appendix A

- Figures:
- Figure 1: Jefferson County Site Location Map with Mining Sites
 - Figure 2: Jefferson County Site Map with Elevated Lead Levels in Residential Soils, 2008
 - Figure 3: Jefferson County Site Location and Demographic Statistics

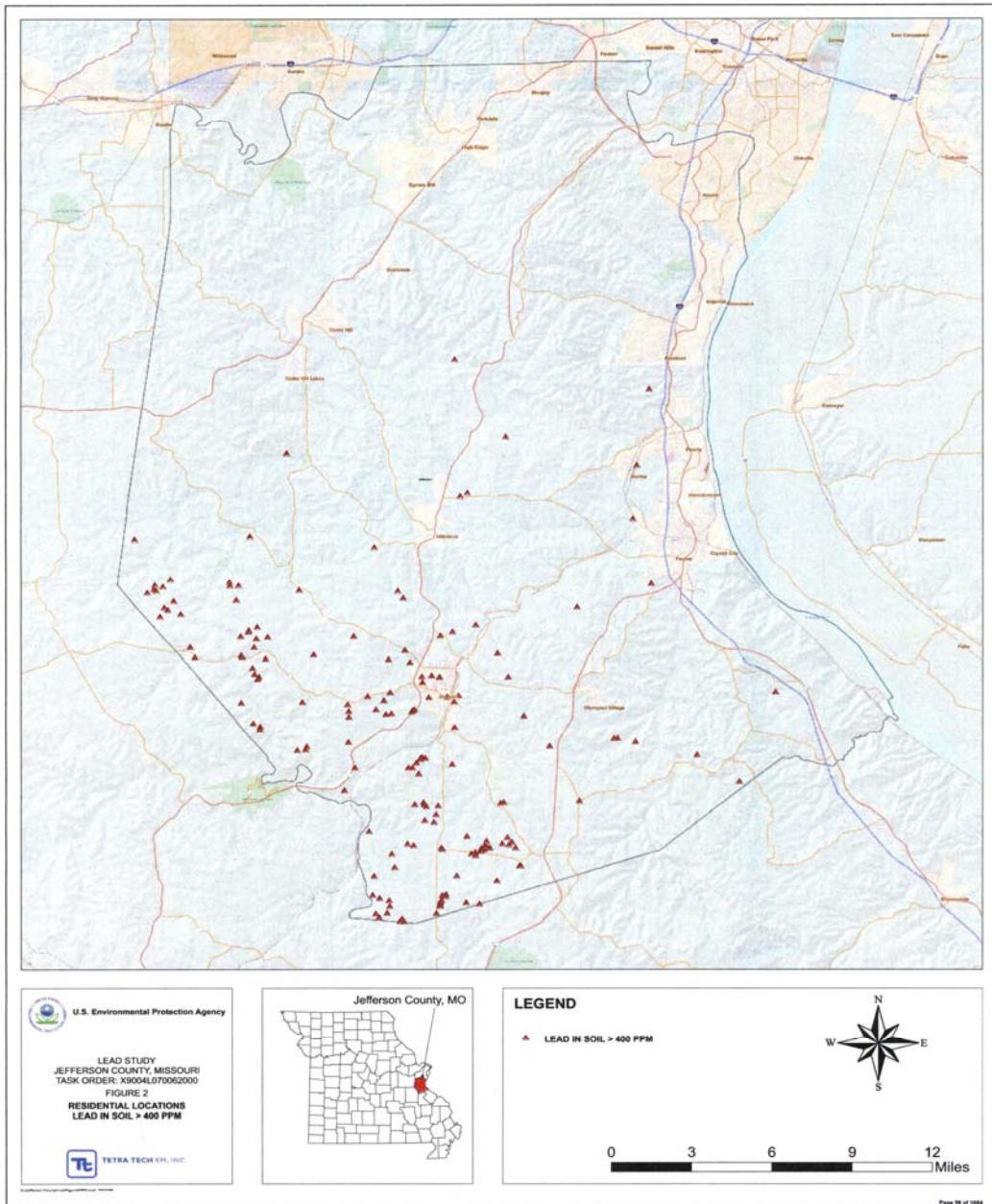
Figure 1
Jefferson County Site Location Map with Mining Sites



Source: Tetra Tech EM, Inc. Preliminary Assessment Report, Jefferson County Lead Site, May 7, 2008

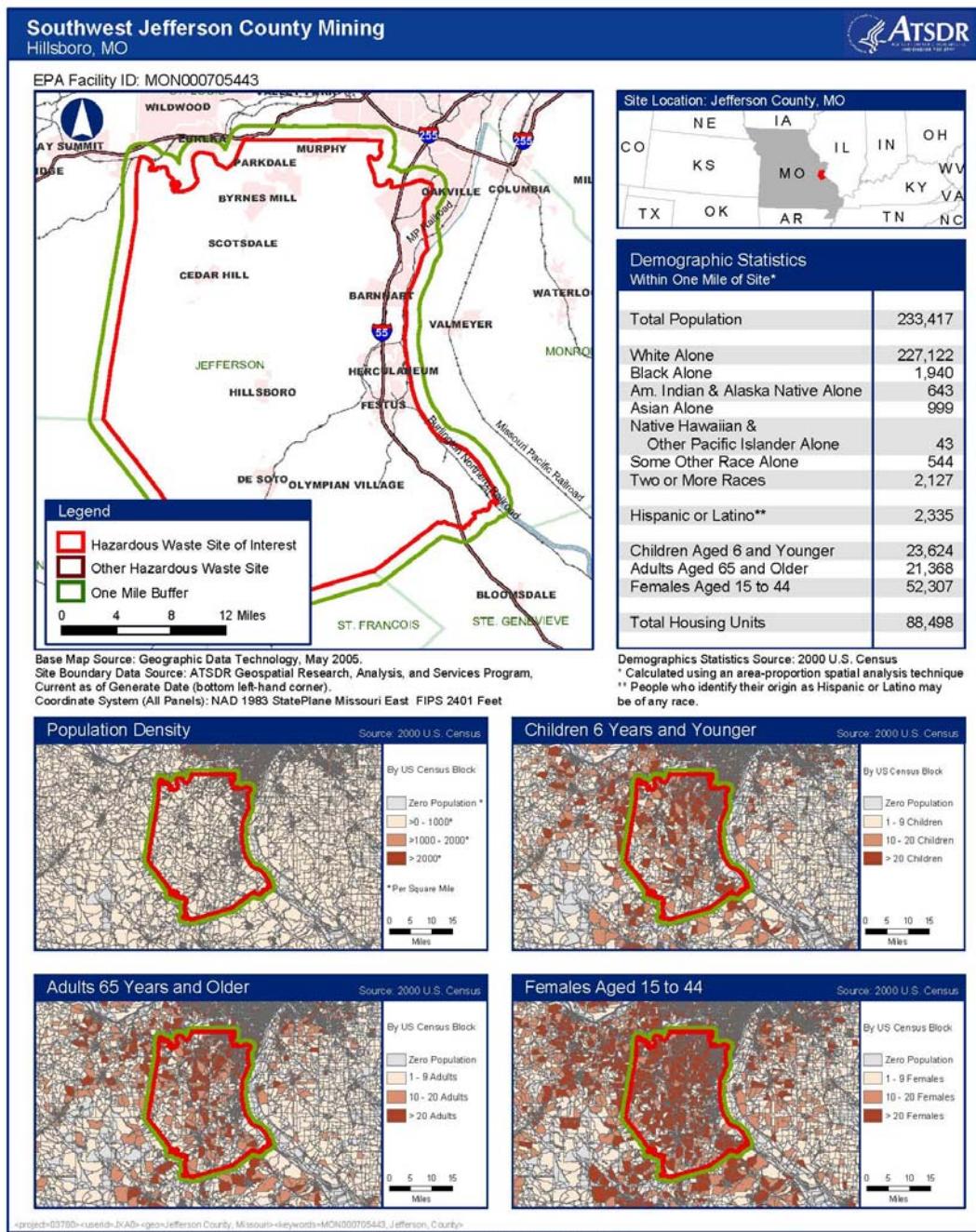
Figure 2

Jefferson County Site Map with Elevated Lead Levels in Residential Soils, 2008



Source: Tetra Tech EM, Inc. Preliminary Assessment Report, Jefferson County Lead Site, May 7, 2008

Figure 3
Jefferson County Site Location and Demographic Statistics



Appendix B

Table 1:

Summary of Contaminants in the Southwest Jefferson County
Mining Site and Health Guidelines

Table 2:

Southwest Jefferson County Mining Site Exposure Pathways

Table 1
Summary of Contaminants in the Southwest Jefferson County Mining Site and Health Guidelines
 Levels are in parts per million (ppm) unless otherwise noted

Contaminant	Location	Media	Maximum Level or Range at Residences	Screening Value & Source
Lead	Smelter at Valles Mines	Soil	50,800	400 EPA for residential yards (Residential soils equal to and above 1,200 ppm are remediated under an EPA time-critical removal action. Residential soils between a calculated health risk level [approximately 400 ppm] and 1,199 ppm are remediated under a future Remedial Action)
Lead	Tailings Piles	Tailings	8,820	
Lead	Railroad Bed	Tailings	14,300	
Lead	Residential Soils	Soil	14.7 – 7,280	
Lead	Sediment	Sediment	3,470	
Cadmium	Tailings Piles	Tailings	159	
Cadmium	Residential Soils	Soil	ND – 25.5	5 ATSDR EMEG – child
Arsenic	Tailings Piles	Tailings	28.1*	20 ATSDR EMEG – child
Arsenic	Residential Soils	Soils	ND – 40.4	
Zinc	Tailings Piles	Tailings	151,800	20,000 ATSDR EMEG – child
Zinc	Residential Soils	Soils	31.3 – 1,770	
Lead	Drinking Water Wells	Water	1 – 94 ppb †	15 ppb EPA PDWS
Barium	Drinking Water Wells	Water	10.8 – 1,640 ppb †	2,000 ppb EPA MCL
Cadmium	Drinking Water Wells	Water	ND – 21.1 ppb	5 ppb EPA MCL
Arsenic	Drinking Water Wells	Water	ND – 7.25 ppb †	10 ppb EPA MCL

References 1,3,10,13,14,15

ppb = parts per billion

EPA PDWS = Environmental Protection Agency Public Drinking Water Action Level

EPA MCL = Environmental Protection Agency Maximum Contaminant Level for Public Water Supplies

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide

ND = Not Detected

* Limited number of samples analyzed

† One unusual well sample (#3388-070) contained 3,070 ppb lead, 6,490 ppb barium, and 10.2 ppb arsenic, but reportedly had dirt in the water.

Table 2
Southwest Jefferson County Mining Area Site Exposure Pathways

Pathway Name	Exposure Pathways Elements					Time	Type of Pathway
	Source	Environmental Medium	Point of Exposure	Route of Exposure	Receptor Population		
Soil	Mining and Smelting Waste, Contaminated Landscape Soil	Soil	Smelting and Tailings Areas, Private Yards, and Driveways	Ingestion and Inhalation	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Indoor Dust	Mining and Smelting Waste	Soil Dust	Inside Homes	Ingestion and Inhalation	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Groundwater	Mining and Smelting Waste	Groundwater	Private Drinking Wells	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Completed
Sediment	Mining and Smelting Waste	Sediment	Tailings Areas, Streams, and Ponds or Lakes	Ingestion	Residents, Visitors, and Transient Populations	Past, Present, and Future	Potential
Surface Water	Mining and Smelting Waste	Surface Water	Area Streams and Lakes	Ingestion	Stream and Lake Users	Past, Present, and Future	Potential
Fish	Mining and Smelting Waste	Fish	Locally Caught Fish	Ingestion	Individuals Eating Locally Caught Fish	Past, Present, and Future	Potential
Edible Plants	Mining and Smelting Waste	Edible Plants	Locally Grown or Gathered Plants	Ingestion	Gardeners and Individuals Eating Plants Gathered in the Area	Past, Present, and Future	Potential